

IEA Task 33 Meeting

Gothenburg, Sweden

2013-11-19-21

Country Update Sweden



Lars Waldheim

Alsätravägen 130

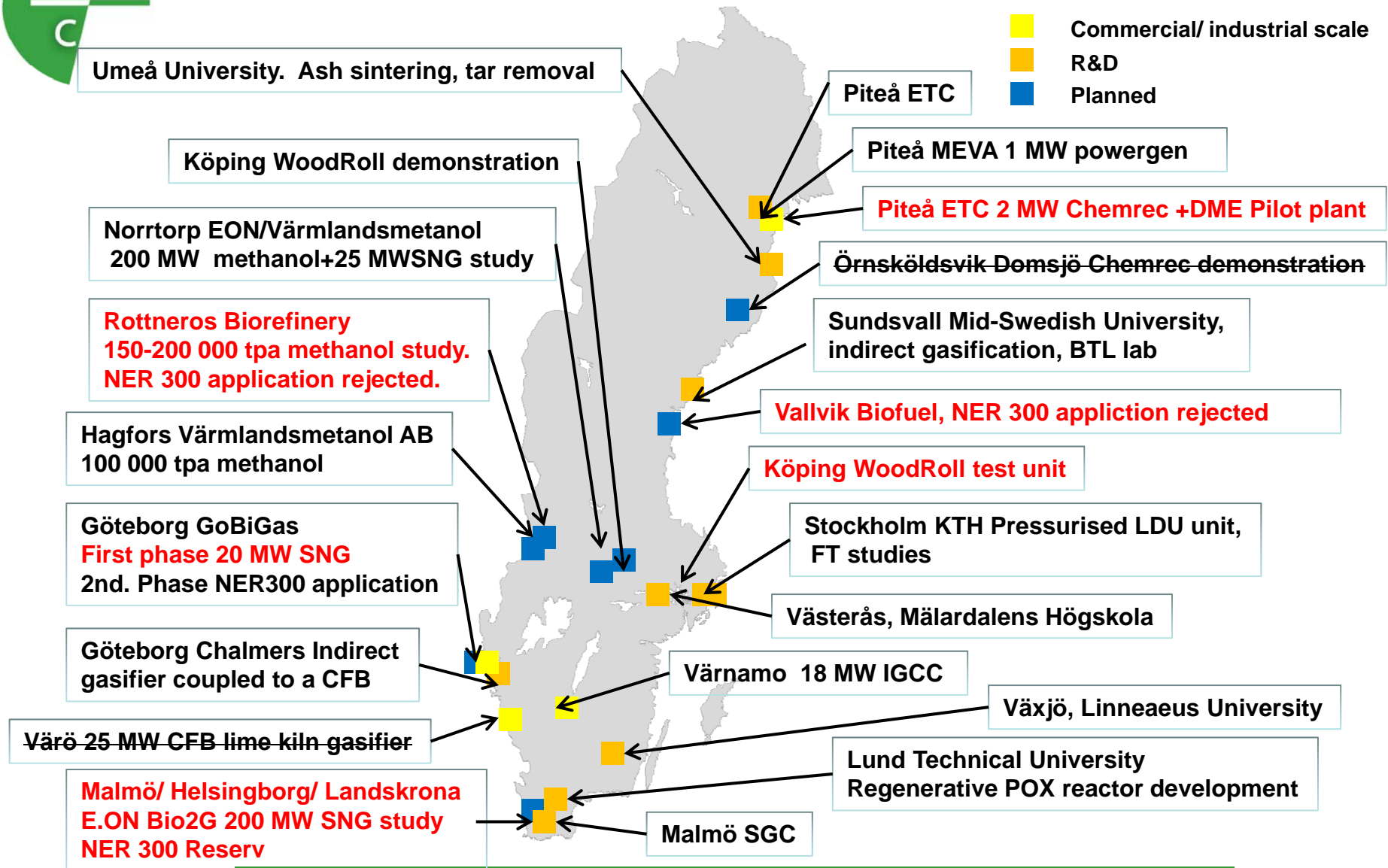
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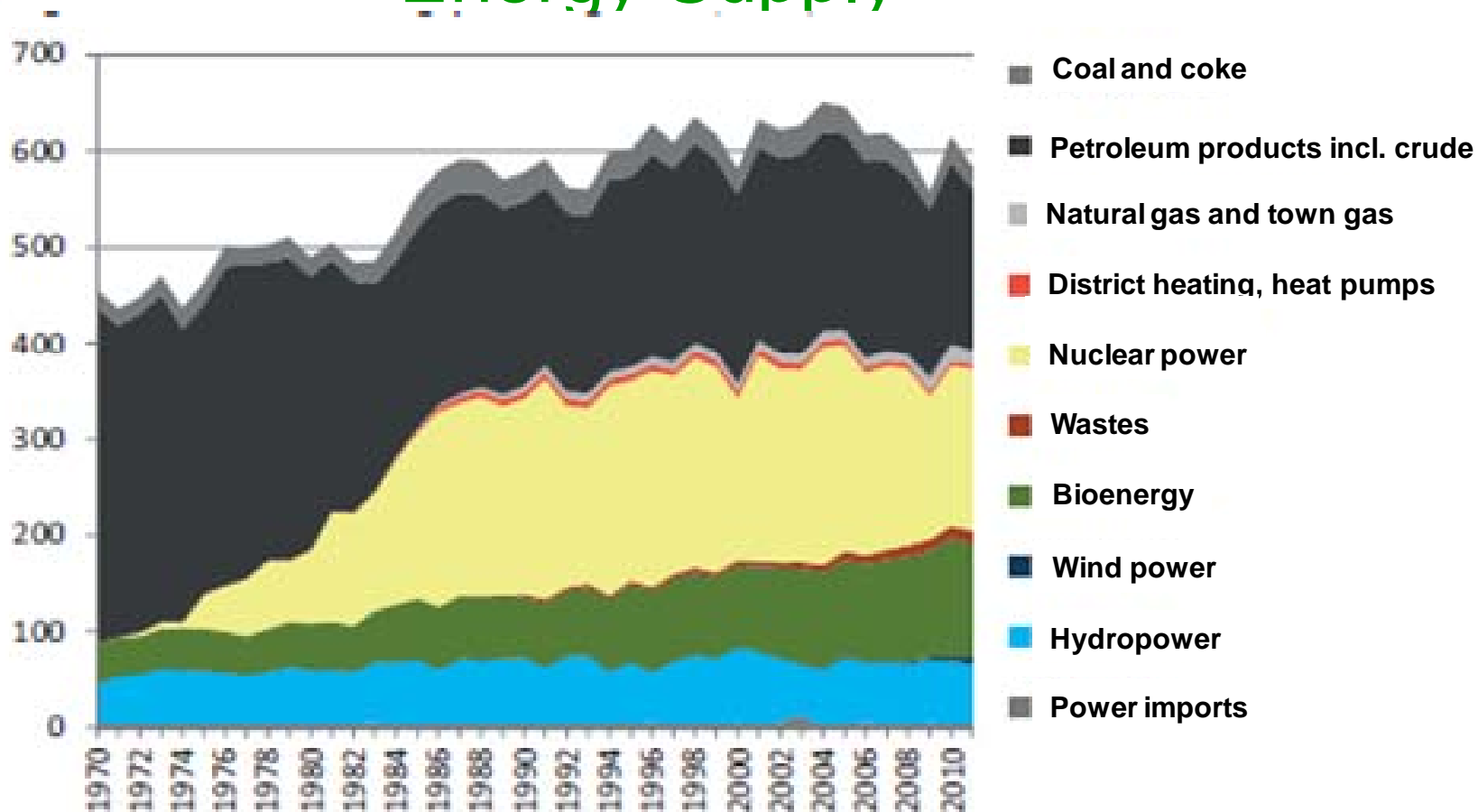


Biomass Gasification Sweden 2011





Energy Supply



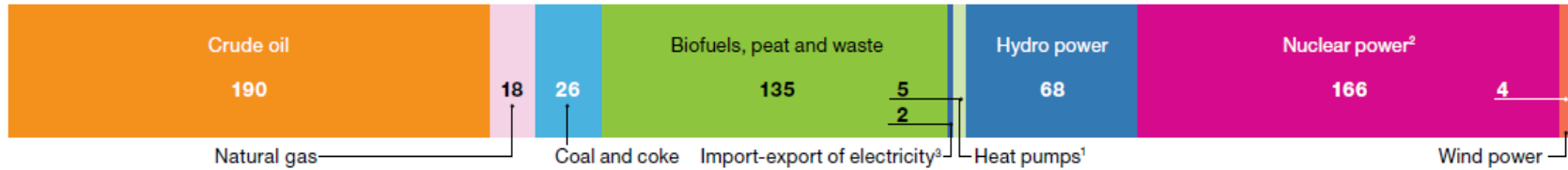
Source: Energimyndigheten, SCB

In 2009 biomass surpassed oil (less transport fuel) as input energy in Sweden
In 2010 biomass was 32%, 137 TWh, hydro+nuclear 107 TWh 2009



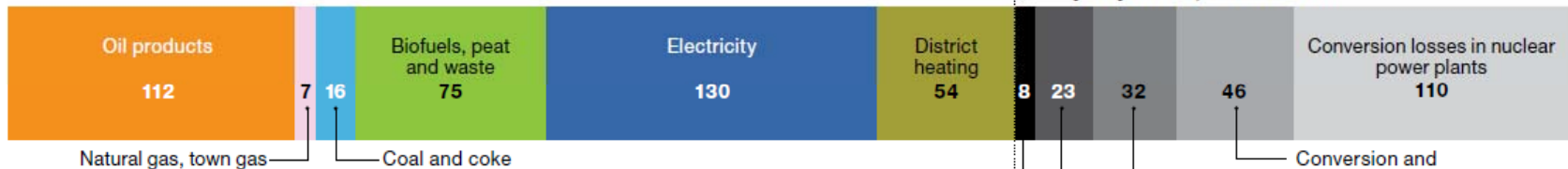
Energy balance 2010

Total energy supply, by energy carriers, 614 TWh

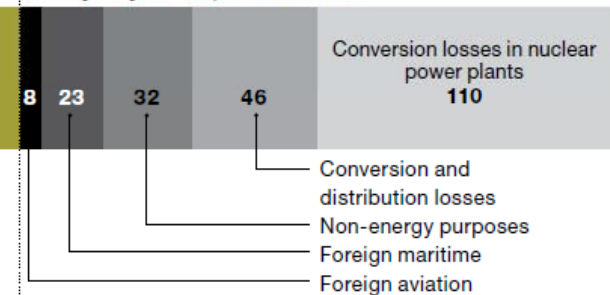


Conversion in power and heating plants, refineries, gasworks, coking plants and blast furnaces. Distribution of electricity and district heating, together with international bunkering and supply of energy raw materials to such users as the paint and chemical industry.

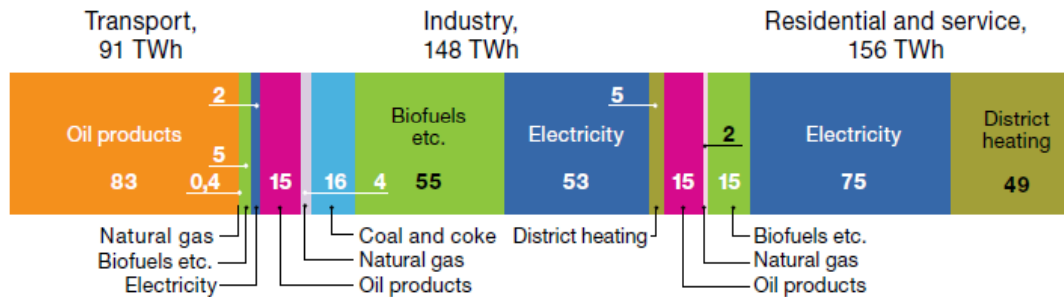
Total final use, by energy carriers, 395 TWh



Losses and use for non-energy purposes, 219 TWh

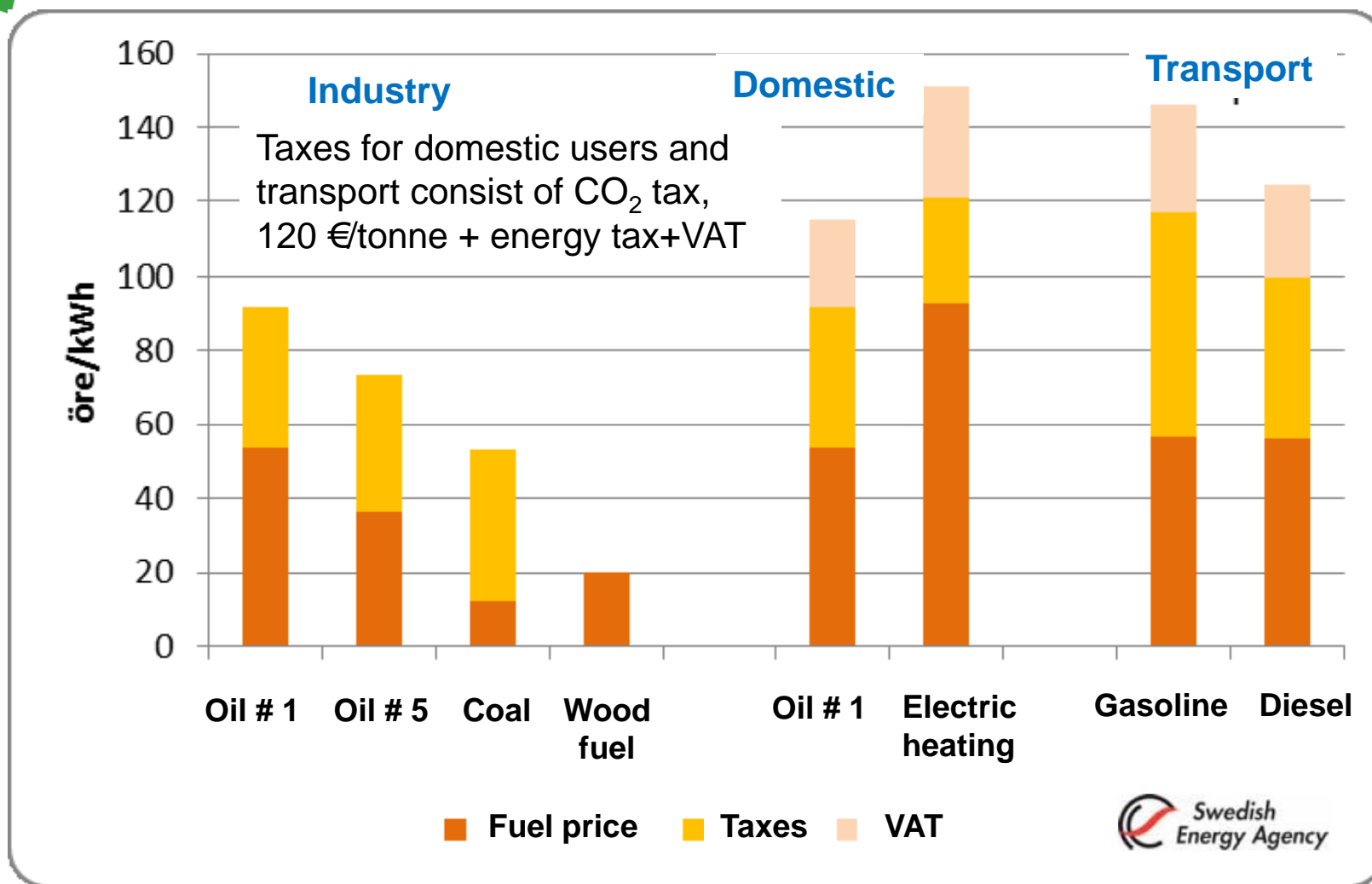


Total final energy use, by sectors, 395 TWh



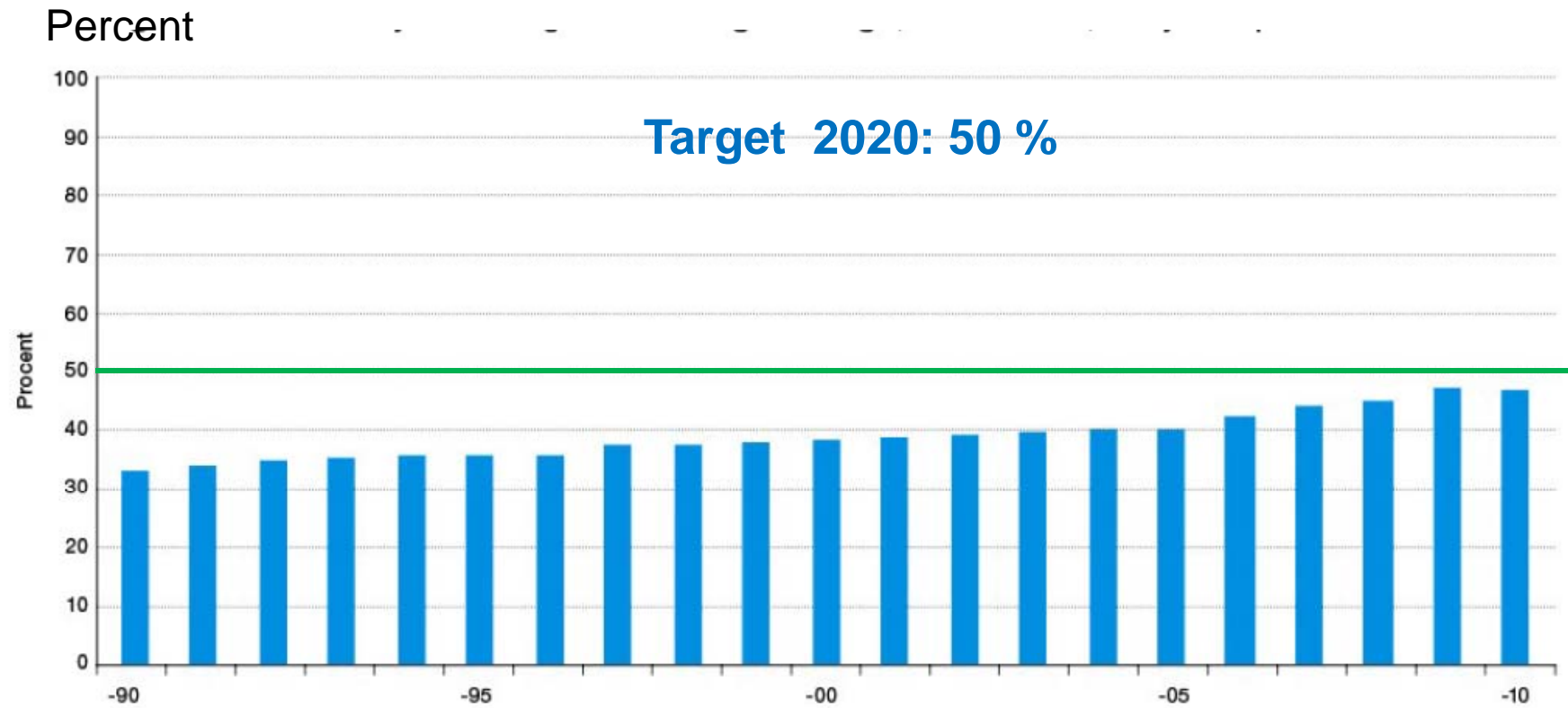


Fuel prices and taxation 2010





Renewable energy fraction





Swedish Energy Targets 2020

- Reduce GHG emissions 40 % by 2020 outside ETS sector
 - 20% done (rel. 1990), 30% by flexible mechanisms
 - Continued use of environmental taxation
 - Sweden independent of fossil transport fuels in 2030
- Follow EU ETS policies (now third phase)
- Minimum 50% Renewable Energy 2020
 - RE Certificate prolonged and coordinated with Norway target increased, +25 TWh rel. 2002
 - Wind power planning 20 TWh land-based+10 TWh sea-based
 - 10% renewable transport fuels
- Energy Savings Plan
 - 20% reduction of energy/GNP by 2020, relative to 2008
- Nuclear power
 - The reactor development law (SFS1984:3) is revoked
 - Up to 10 new replacement reactors can be accepted on present sites



Renwable transport fuels

• Present situation

- 11.8 % RE transport fuels in 2012
- 5.9 % of all vehicles predominant RE fuels
- Energy taxes levied on low-level blends in gasoline and diesel as of 2013 to comply with EU state aid rules, but no CO₂ tax.
- Tax exemptions retained for high-level blends or neat fuels (e.g. E85, B100, CBG, but also for HVO < 15 % in diesel)
- Sustainability criteria to qualify as RE fuel and for tax exemptions

• Future plans

- Quota obligation and increase for RE fuels 4.8 to
 - 7 vol% in May 2014
 - 4-7 to 9.5 vol % of which 3.5 % is specially designated fuels
- Parliamentary commission on fossil-free vehicle traffic to be reported December 16, 2013.
 - Proposal for a price guarantee for second generation biofuels?



NER 300

– EU NER300: bioenergy 5 of 9 proposals, 3 retained

- Pyrogrot Billerud -Category: 40 kton/a pyrolysis oil or slurry
- GoBiGas 2 -Category: 40 million Nm³/a SNG
- E.ON Bio2G -Category: 40 million Nm³/a SNG, **reserve**

– National agencies confirmed approved projects.

– New round of applications in 2013

- E.ON Bio2G -Category: 40 million Nm³/a SNG



R&D and D

- Government Bill “A Boost to Research and Innovation” 2010 gives support to 20 identified “Strategic Areas of Research” in 43 groupings for 5+5 years, 3 energy related
 - Bio4Energy (UmU/LTU/SLU)
 - Biorefining of woody biomass 50 MSEK per year
 - Chalmers Energy Initiative (Chalmers, SP, Innventia)
 - Energy Combines, electricity propulsion systems and hybrid vehicles, large-scale renewable electricity generation and grid integration, technology impact assessment, 58 MSEK/year
 - STandUP (UU/KTH/LTU/SLU)
 - Mainly electrical grid and vehicle technology, but also RE power generation
- Swedish Centre for Renewable Fuels (f3) launched
- Swedish Gasification Centre launched



Swedish Gasification Centre (SFC)



CDGB - Centre for Direct Gasification of Biomass

CIGB – Centre for Indirect Gasification of Biomass

B4G – Biomass for Gasification, Entrained Flow Centre

Academies Chalmers, Gothenburg Univ., KTH, Linnaeus Univ., Luleå Technical Univ., Mid-Swedish Univ., Mälardalen Univ., Umeå Univ.

Companies E.ON, Metso, Göteborg Energi, Fortum, Mälarenergi, Cortus, Nynas, Eskilstuna Energi och Miljö, Nordkalk

Application for 4 year activity, 58 MSEK/year 2013-2017 approved



Swedish Gas Centre

”Energy gas program”

New project period 80 MSEK, 9 M€ for 2013-2015

On-going gasification related activities

- ***Gasification- Status and Technology and gasifier database***
report SGC 240 2012, database on SGC homepage in 2011
- ***Co-production of SNG and FT diesel***
PhD work at KTH, results published in 2012
- ***International Gasification Seminar***
Gothenburg, October 16-18, 2013
- ***Particulate contaminants from indirect gasifiers***
- ***Autothermal regenerative POX tar reactor***
- ***On-line detection of water vapor***
- ***CO₂ removal in indirect gasification***
- ***Fuel tests in 500 kW Wood Roll prototype***
On-going, KTH, Cortus





Swedish Centre for Renewable Fuels (f³)

"f3 will be established as a nationwide knowledge platform and venue for cooperation in the production of renewable fuels and the related system aspects, with highest international credibility"

Universities

- Chalmers
- Royal Inst. Techn.
- Lund Inst. Techn.
- Swedish Univ. of Agricultural Science
- Bio4Energy*

Research institutes

- Swedish Tech. Res. Inst.
- Swedish Env. Inst.
- Innventia

**Budget for 2011-13
30 million SEK**

Industry

- Preem
- Perstorp
- Göteborg Energi
- Eon Sweden
- Sekab E-technology
- Volvo Technology
- Scania

Funding

- Swedish Energy Agency
- Region of Västra Götaland

* Cooperation between Umeå university, Luleå technical university and SLU in Umeå.

f3 has five different project areas:

- **System-wide studies**
- **Comparative studies of various systems for renewable fuels**
- **Analyses of synergies between plants**
- **Analysis of synergies between different technology platforms**
- **Method development for interdisciplinary studies in above four areas**

fossil free fuels f³



Thermo-chemical Conversion of Biomass

- Long experience of R&D within gasification. Activities started in the 1970s.

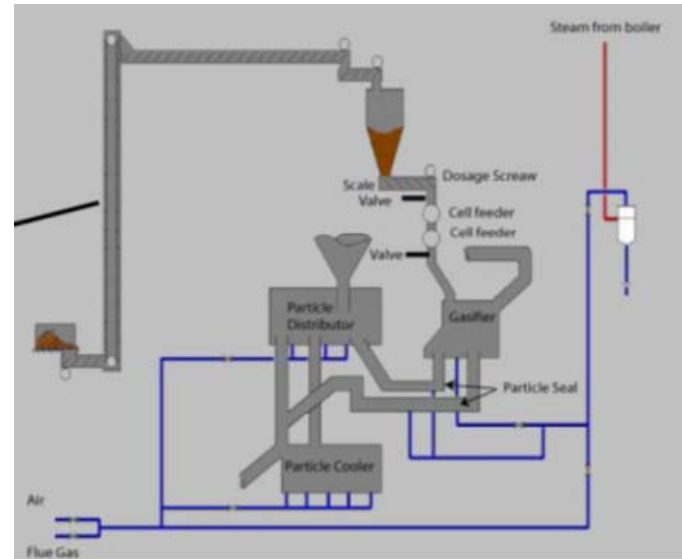
Technologies at KTH

- 75 kW pressurised (30 bar) & air & steam/oxygen FB gasifier with secondary reactor
- 50 kW air & steam/oxygen FB gasifier
- 5 kW air & steam/oxygen FB gasifier
- Test rigs for catalytic deactivation and particle separation concepts
- Tar analysis equipment, On-line alkali analyses
- **New major grant (500 000 €) for upgrading research infrastructure**



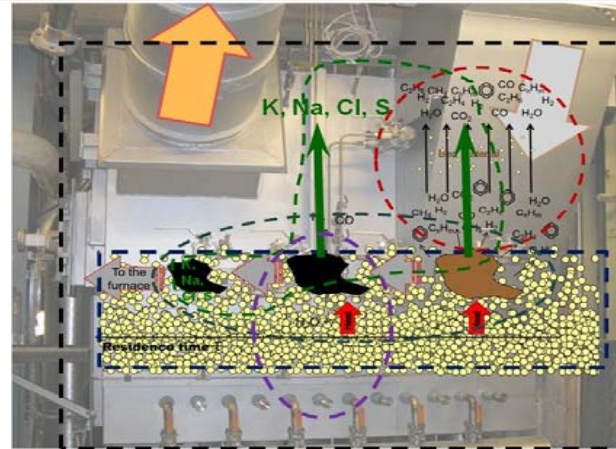


Chalmers Indirect Gasification



Chalmers 2-4 MW_{fuel} gasifier integrated on the return leg of Chalmers 12 Mw_{fuel} CFB boiler.

Operation time ~ 8000 h whereof ~ 1300h experimental time with fuel.



CHALMERS
UNIVERSITY OF TECHNOLOGY



Chalmers Technology development

- Goal of activity

- Demonstrate how an indirect gasifier could be built +100 MW_{fuel}
- Demonstrate a robust method for catalytic reformation of the gas to a syngas containing only CH₄, H₂, CO, CO₂ H₂O
- Demonstrate a energy efficiency for dry biomass to clean syngas >85%

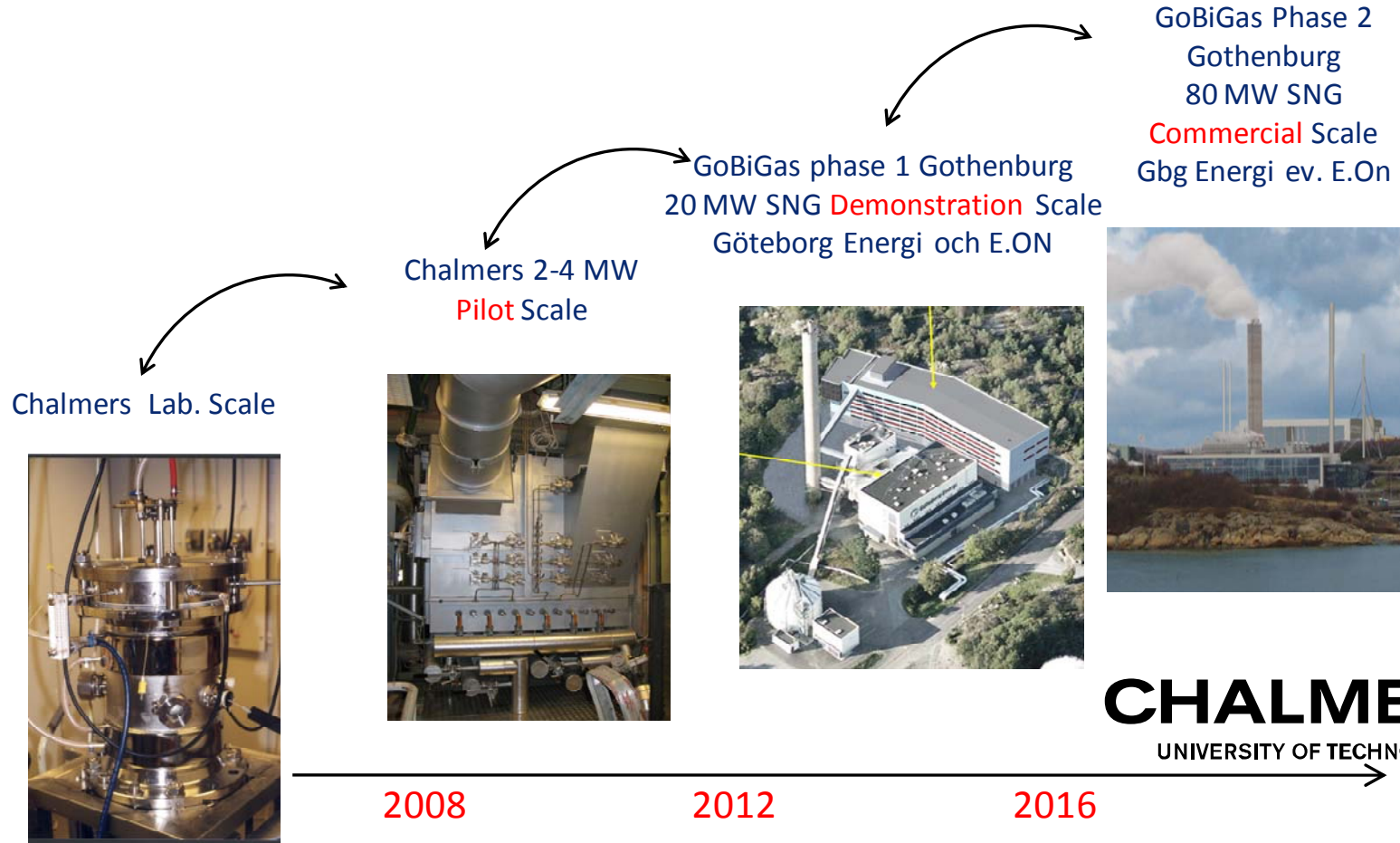
2012-2013 season activity

- bed materials
- chemical looping reforming.



Chalmers

Biogas Production via Thermal Conversion - From Research to Commercial Production



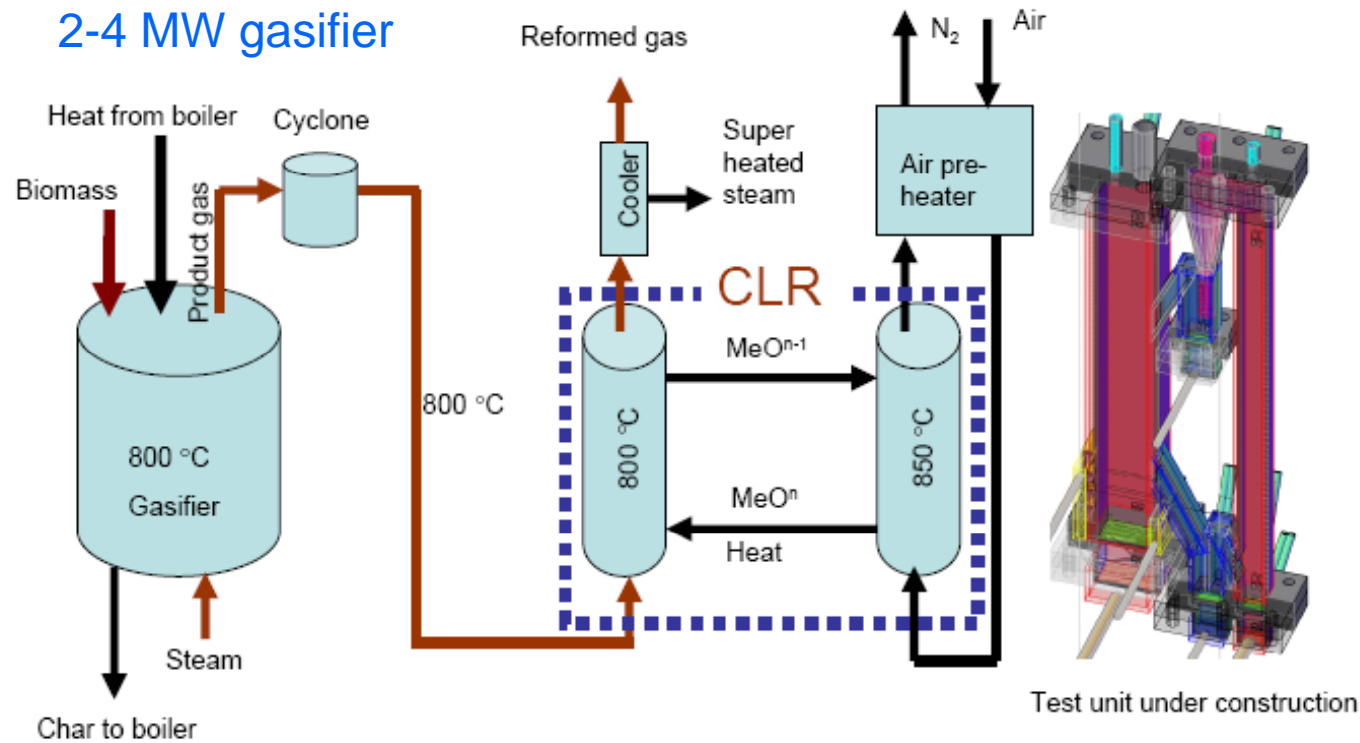


Chalmers Indirect Gasification



Chemical Looping Reforming

Scale of tests: 2-3 l/min raw gas



CHALMERS
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ETC Gasification Activities

Host for DP1: Chemrec black liquor, biomass

VIPP gasifier: biomass, cyclone gasification, WESP, scrubber, engine CHP

PEBG: Pressurised entrained flow gasification, 1 MW, 15 bar

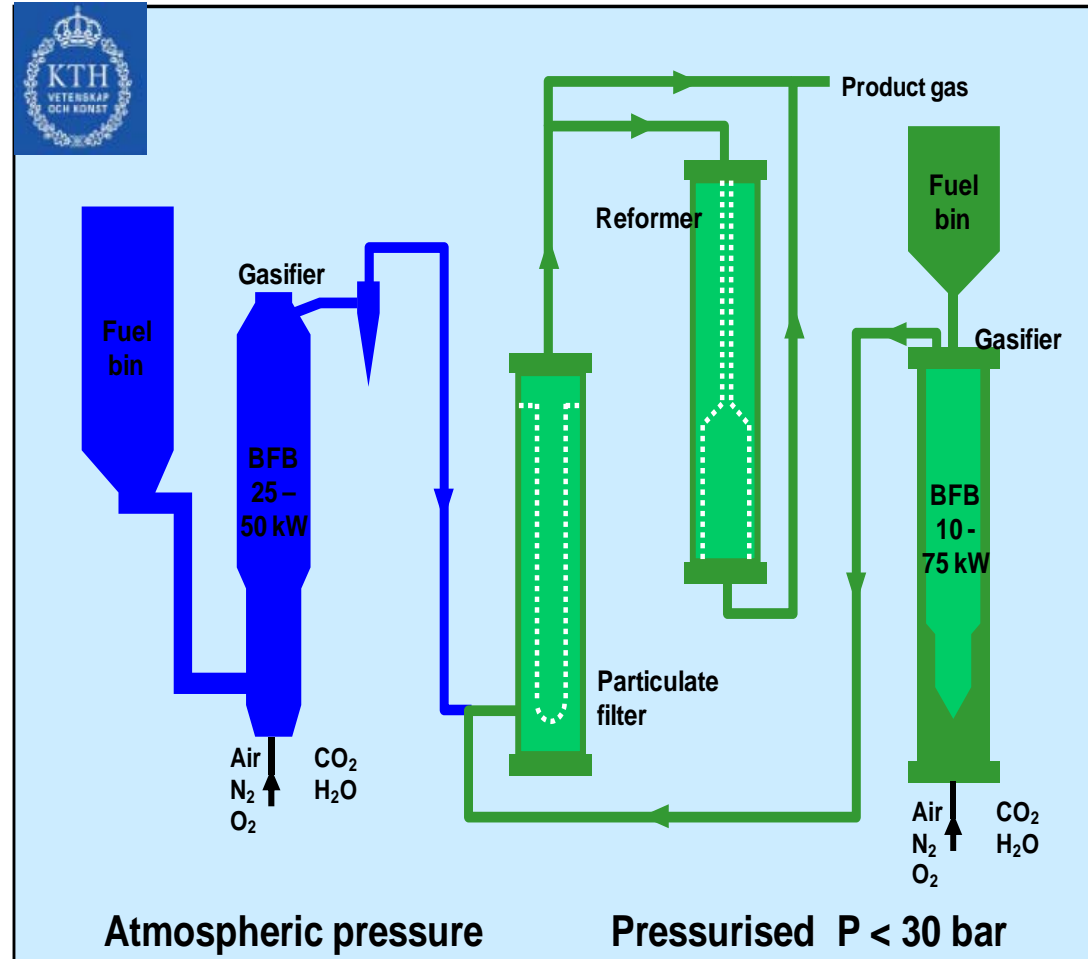


Synthesis gas: zeolithe membrane reactor/MeOH, one stage DME pilot



Projects

- HT-SNG: Demonstration of improved catalysts and reactor designs for the production of SNG
- SNG for smart gas grids
- SYNCON: Novel synthesis process concepts for efficient chemicals / fuel production from biomass (SYNCON)
- DeMiTar: Development and market implementation of PID and FID tar analyzers





MiUn BTL Research Laboratory



150 kW ICFB gasifier.



- Integration of FT synthesis reactor
- Prove BTL integration
- System modelling
- Work on Fuel flexibility



Black Liquor Gasification Activities

Pictures from site March 2011



(In commissioning! First BioDME expected first part of May)



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CHEMREC
Energy to Succeed



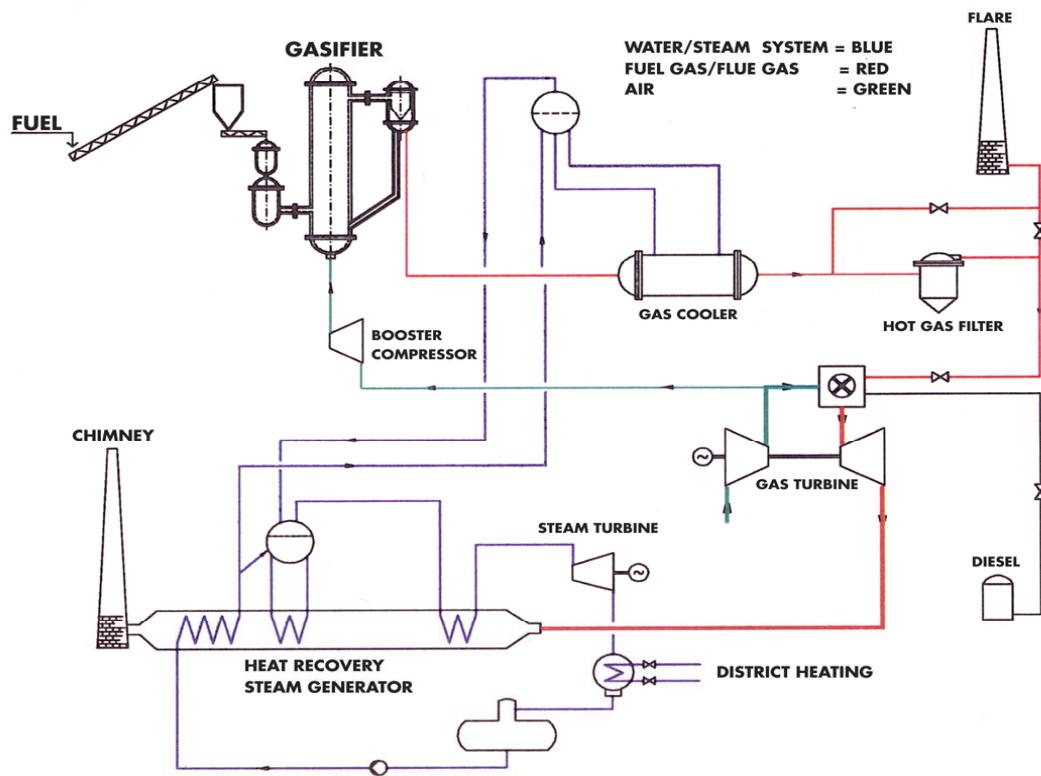
LTU Biosyngas program

- **The Luleå Technical University has bought the plant**
- **Operating staff and some key Chemrec staff hired**
- **LTU Biosyngas program, approx. 250 MSEK, under negotiation for period 2013-2015**



Värnamo -Pressurised combined cycle

Mothballed again since 2011.



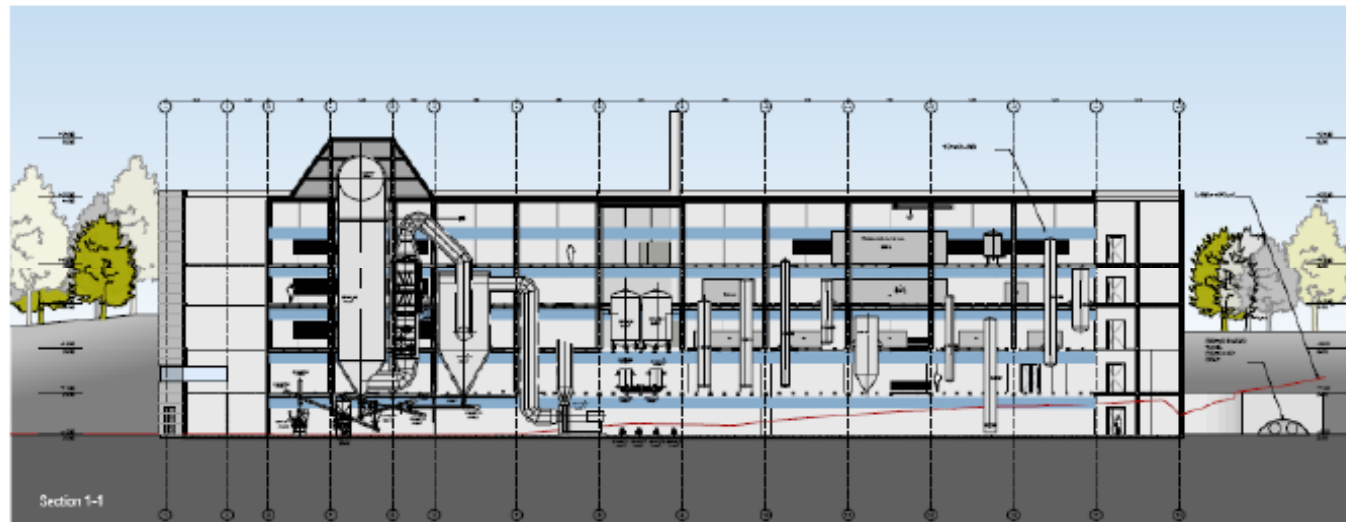
- Supplier: Bioflow (Foster-Wheeler, Sydskraft)
- Fuel 18 MW
- Power 6 MW
- Heat 9 MW
- 18 bar pressure
- Typhoon GT
- **Mothballed in 2000.**
• **> 8000 gasifier and 3 600 hours of GT op.**



Biomass to SNG: GOBIGAS

GoBiGas – phase 1

Production:		Consumption:	
Bio-SNG	20 MW	Fuel (pellets)	32 MW
District heating	4 MW	Electricity	2,5 MW
Heat to heat pumps	8 MW	RME (bio-oil)	0,5 MW



 Göteborg Energi



Biomass to SNG: GOBIGAS

GoBiGas – step by step

- **Performance goals:**

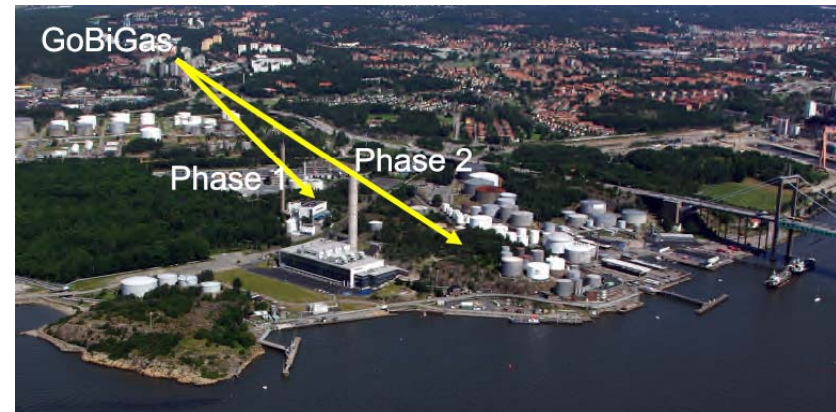
- Biomass to biomethane 65 - 70%
- Energy efficiency > 90%

- **Phase 1:**

- Demonstration plant
- Evaluation, R&D programme
- 20 MW generating 160 GWh/year
- In operation early 2013
- Allothermal (in-direct) gasification

- **Phase 2:**

- 80-100 MW generating 640-800 GWh/year
- In operation after evaluation of Phase 1
- Technology not yet chosen



**Official start-up initiated
October 28, 2013.**

**Site visit as part of
fall meeting workshop**





E.ON Bio2G

- Fuel input ~345 MW_{th} (including Power Island)
- Biogas production 202 MW, ~21 000 m³/h
- Biogas efficiency 60-65% (excl. ASU)
- Total efficiency up to 80%
- Power production 14 -23 MW (for internal use)
- Heat production up to 55 MW (depend on fuel moist)
- Total investment: ~450 MEUR
- Possible production grant from EU (NER300) 2016-2020 (decision expected end of 2012).
- Three good sites identified for E.ON Bio2G localisation (Malmö, Landskrona and Helsingborg)



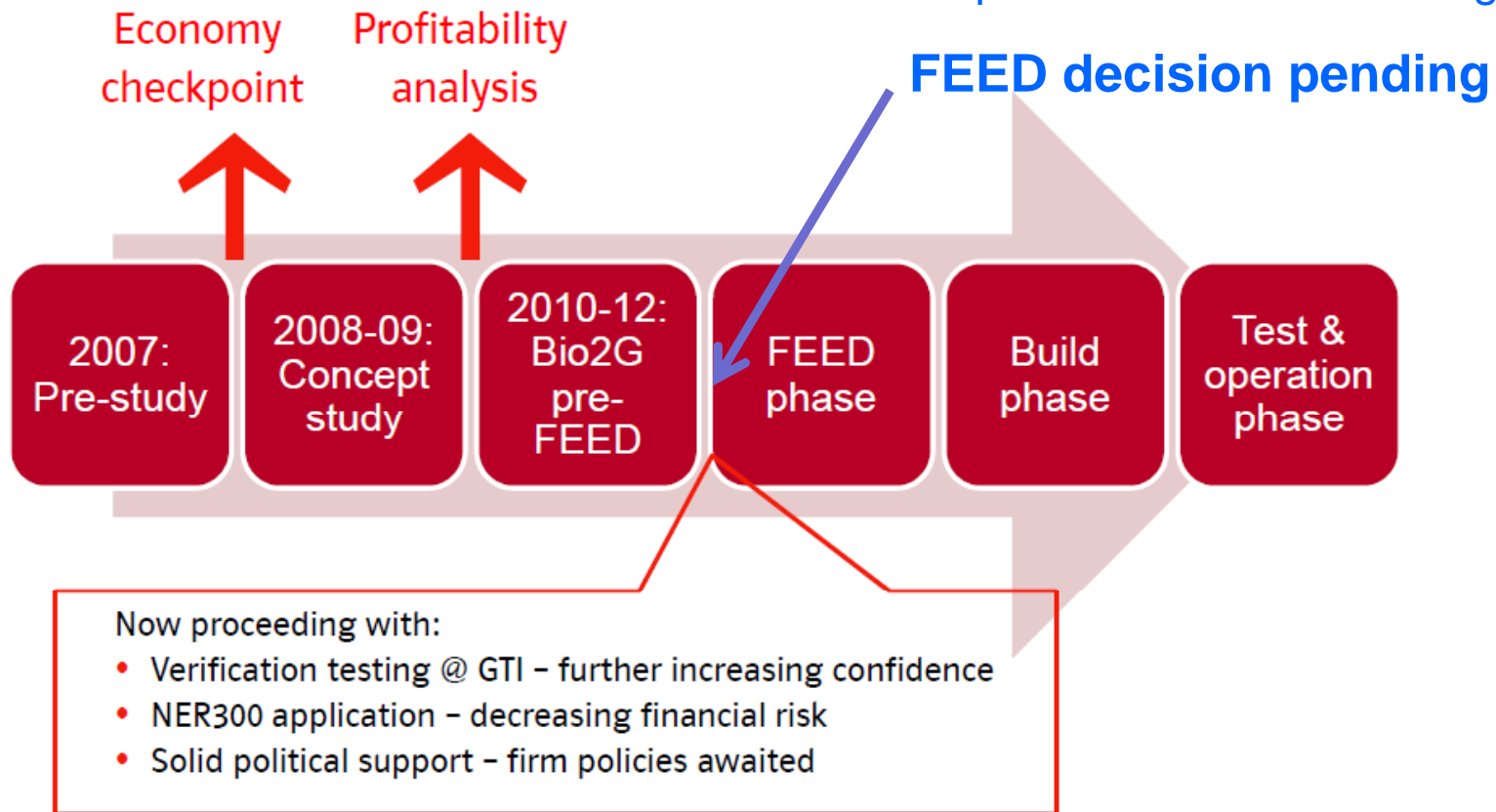
“Lighthouse” candidate for first-mover support,
i.e. NER300, EIBI, etc



E.ON Bio2G

Bio2G – main time schedule

Studies with Carbona and Haldor Topsøe and others are on-going



©GC Seminar October 16-17 2013



Värmlandsmetanol

Permitting is on-going. No grant financing requested.
Private investors and public IPO expected to raise 3 000 MSEK (330M€)
Planned construction start "as soon as permits are in place".

VärmlandsMetanol, Sweden HTW Biomass to Methanol Project

- Uhde selected as technology supplier and EPC contractor
- **Plant Capacity:**
100,000 t/a of fuel grade methanol + district-heating 15 MW_{th}
- **Feedstock:**
Domestic forest residue, ~25 t/h
- **Process:**
Fluidized bed gasification (HTW)
(eq. 111 MW_{th})



Flygfoto: Lars Nilsson Montage: Struder

VärmlandsMetanol AB

Uhde



ThyssenKrupp



MEVA Innovation AB

Test unit, 500kW thermal with 100 kW gas engine in operation at ETC, Piteå.
A first commercial unit, 1.2 MWe is under commissioning at Hortlax, Piteå.
Target market is co-gen plant, 2-20 MW heat, 1-10 MWe electric,

VIPP-VORTEX®, Gasification system

VIPP Cyclone
Gasifier

VORTEX INTENSIVE
POWER PROCESS



VIPP-ECP®, Gas cleaning system

Multistage cleaning

- cyclone
- gas cooling
- RME scrubber
- WESP

Gas engine

Cooperation on specially designed gas engines with supplier Cummins Power Generation Ltd., UK.

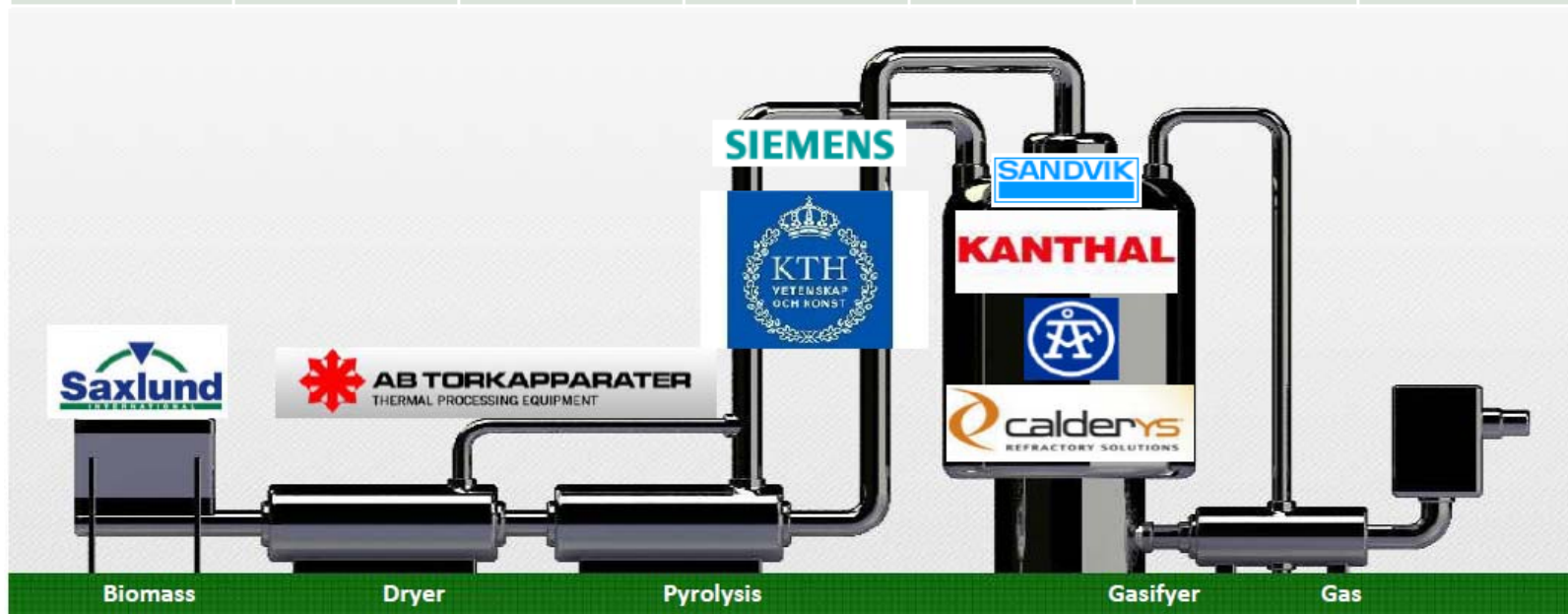
**Hot commissioning started in April.
Some few hours of gasification
has been achieved up to now.**





Cortus Wood Roll

Saxlund International / Opcon AB	Torkapparater AB	KTH Royal Institutue of Technology	Sandvik Heating Technology AB – Kanthal	ÅF	Calderys AB	Siemens
Saxlund International / Opcon delivers biofuels feeding equipment to the WoodRoll® process	Torkapparater delivers dryer and pyrolysis equipment to the WoodRoll® process	KTH has provided equipments and facilities for Cortus to run tests on over 20 different fuels	Kanthal delivers radiation tube burners for indirect heating to the WoodRoll® process	ÅF provides Computational Fluid Dynamics modeling for system optimization	Calderys delivers refractory materials to the gasification reactor in the WoodRoll® process	Siemens delivers Control systems and instrumentation





Cortus Wood Roll

The 500 kW plant

- Indirectly heated gasification in industrial scale
- Successful Syngas (CO/H_2) production during autumn 2011
- Financed by the Swedish Energy Agency, Swedish Iron and Steel Society (Jernkontoret), Movexum, AGA Gas AB and Cortus AB
- Relocation to Köping planned.

Relocation successfully made in early 2012 and test operation on-going



Construction of the plant



WoodRoll® technology in action





Cortus Wood Roll

DETAILS OF THE DEMO PLANT

Location	Southeast Sweden
Power	5MW (Future: 25MW)
Fuel	30 TPD DS of Biomass
Product	1 550 Nm ³ /h synthesis gas
Investment	€6,5 Million
Unit Price	20 € per MWh (2 + 10 year supply contract)
Environmental permit	Granted in December 2009
Energy supply contract	Signed in July 2010

Following 500 kW tests, the planned 5 MW unit has been postponed for economical reasons (low price of coal and emission rights).

EXPANSION – STAGE 2 = 25MW

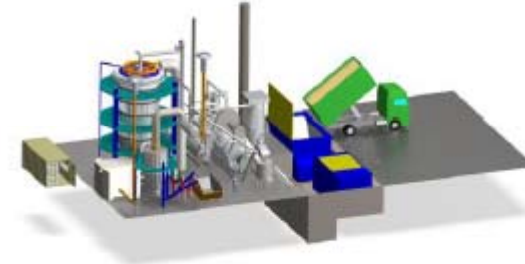


Photo of industrial area of customer site in Sweden.

